

PARTICULATE MATTER HEALTH EFFECTS



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OVERVIEW

Particulate Matter:

- **A Pollutant with Multiple Personalities**
- **Health Effects**
- **Exposure Considerations**
- **How Can PM Cause Adverse Health Effects?**
- **Take-Home Messages**

A Pollutant with Multiple Personalities

~ 15-50 km

Earth's Protective Ozone Layer

~ 10-15 km

UV

UV

UV

UV

UV

The air we breathe...

Secondary Pollutants

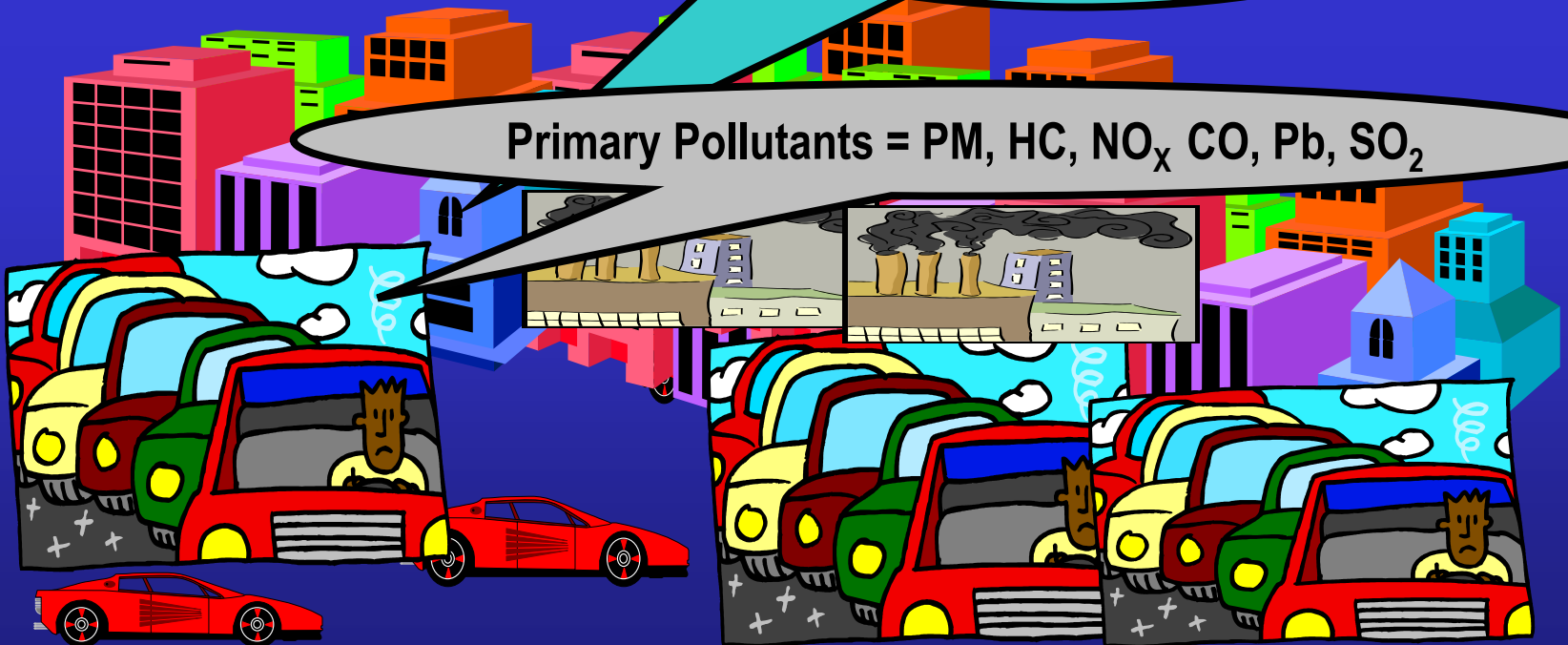
$\text{HC} + \text{NO}_x \rightarrow \text{Oxidants (O}_3, \text{PAN)}$

$\text{O}_3 + \text{NO} \rightarrow \text{NO}_2$

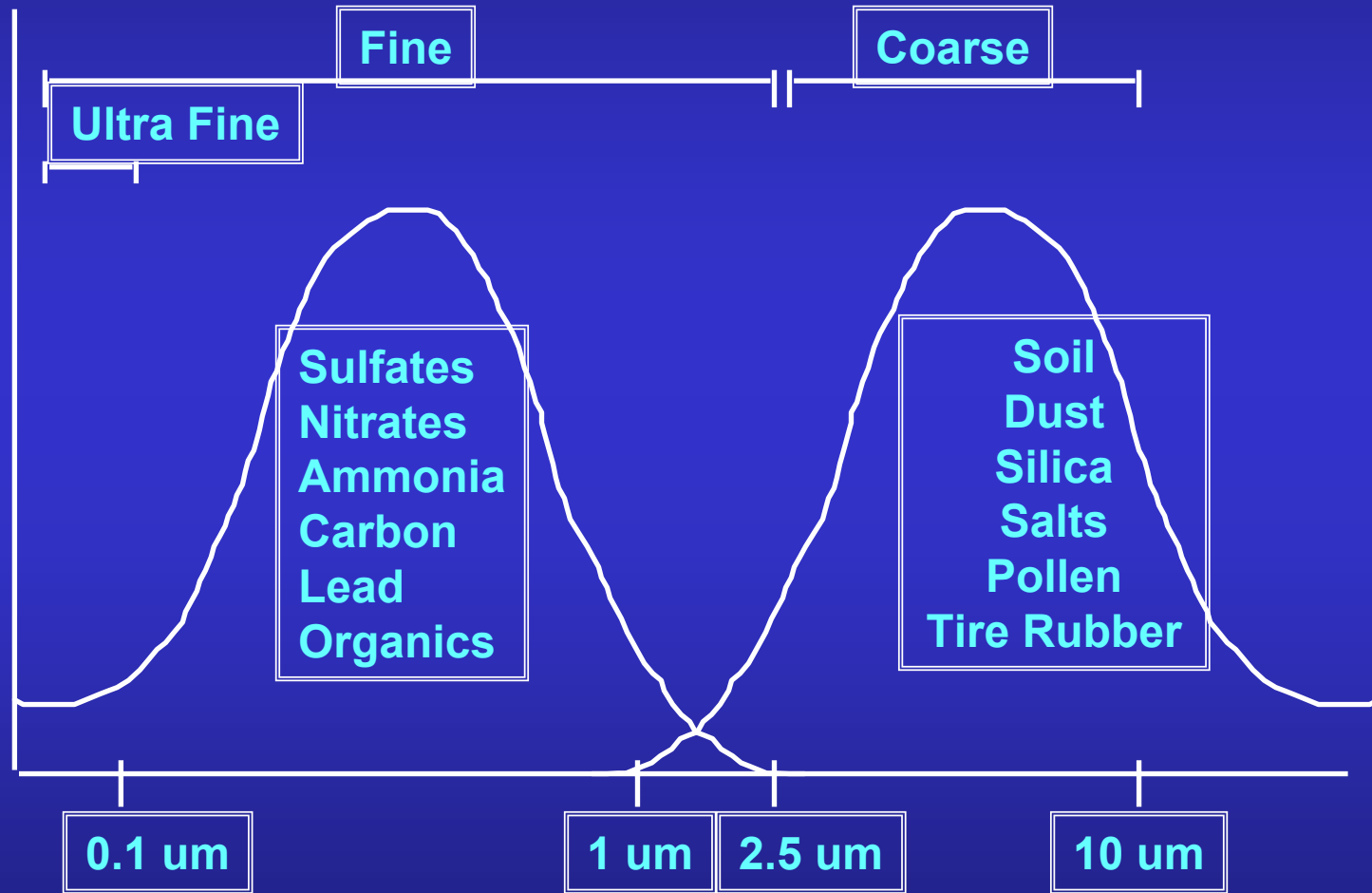
$\text{O}_3 + \text{NO}_2 \rightarrow \text{NO}_3 \text{ (Particles)}$

$\text{O}_3 + \text{SO}_2 \rightarrow \text{SO}_4 \text{ (Particles)}$

Primary Pollutants = PM, HC, NO_x, CO, Pb, SO₂

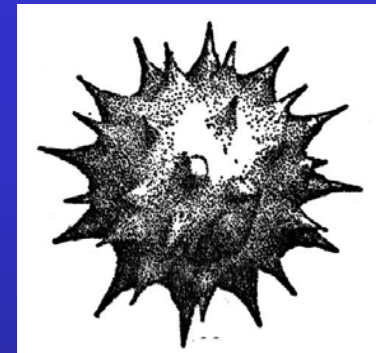
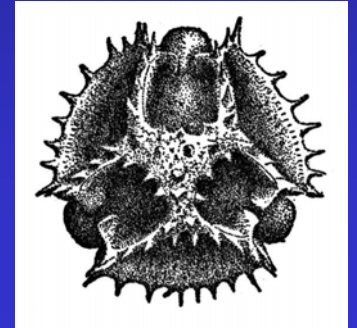
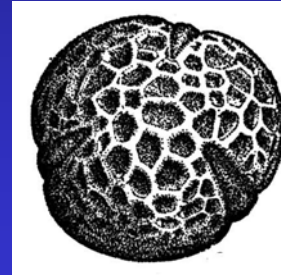


A Pollutant with Multiple Personalities: PM₁₀ Size and Composition



A Pollutant with Multiple Personalities: Allergenic Constituents

- ◆ Pollens
- ◆ Mold & Fungal Spores
- ◆ Latex from Tire Wear
- ◆ Agricultural Product Dusts
- ◆ Particulates & Allergens Interact
 - Diesel & Pollens
 - PM10 & Endotoxin



Health Effects: Historical PM Episodes

♦ Increased Mortality

- Most deaths due to respiratory or cardiovascular causes
- Most in elderly and those already ill

♦ PM Episodes

1930 Meuse Valley, Belgium

1948 Donora, Pennsylvania

1952 London, England

- 4 days before episode 193 deaths/day
- 4 days during episode 406 deaths/day
 > 1995 $\mu\text{g}/\text{m}^3$ British Smoke

“Excessive air pollution for short periods (acute episodes)--

Hazards from atmospheric pollutants have been demonstrated most vividly in episodes of acute exposure. ...A few community catastrophes have resulted from combinations of fog, temperature inversion, and air stagnation, coupled with unusually large amounts of ordinary combustion-produced atmospheric pollutants. In these **rare** but tragic episodes, fatalities occurred predominantly among the elderly and those with pre-existing cardiac or pulmonary disease.”

**Restoring the Quality of Our Environment
Report of The Environmental Pollution Panel
President's Science Advisory Committee
The White House
November 1965**

Health Effects: At Current Ambient Levels

♦ **Acute Mortality:** Short-term (day(s)) Exposures

Daily Time-Series Studies relate the temporal distribution of PM & deaths in large populations

- All-Cause,
Respiratory, Cardiovascular Causes
- Elderly, people with pre-existing disease, neonates & infants
- Similar effects observed in wide range of locations, populations
- Near linear increase in death counts corresponding to increasing PM levels

Health Effects: At Current Ambient Levels

♦ **Acute Mortality:** Short-term(day(s)) Exposures

- **Excess Mortality** (Daily Time-Series Studies)

Percent Change in Mortality

- **All-Cause**

0.5% -to- 1.6% per 10 $\mu\text{g}/\text{m}^3$ PM10

1.0% -to- 2.5% per 10 $\mu\text{g}/\text{m}^3$ PM2.5

- **Respiratory Causes**

1.3% -to- 3.7% per 10 $\mu\text{g}/\text{m}^3$ PM10

- **Cardiovascular Causes**

0.8% -to- 1.8% per 10 $\mu\text{g}/\text{m}^3$ PM10

Health Effects: At Current Ambient Levels

♦ [Chronic] Mortality: Long-Term Exposures

Effects may result from repeated exposures to elevated levels of PM and/or persistent exposure to low-to-moderate levels of PM.

- Available studies compare mortality [or morbidity] among communities with different levels of PM.
- Population-Based or Prospective Cohort
- Use longer-term PM averages: 1+ years

Health Effects: At Current Ambient Levels

♦ [Chronic] Mortality: Long-Term Exposures

Prospective Cohort Studies: Harvard 6-City, ACS

- Percent Change in Mortality *
(After adjusting for individual risk factors)
 - Total (“all-cause”)
3% -to- 9% per 10 $\mu\text{g}/\text{m}^3$ PM10
 - Cardiopulmonary Causes
5% -to- 9% per 10 $\mu\text{g}/\text{m}^3$ PM10

* Source: Wilson, Spengler. 1996. Particles in Our Air.

Health Effects: At Current Ambient Levels

♦ **Morbidity: Short-term (daily) Exposures**

- **Excess Morbidity (Daily Time-series Studies)**

Hospital Admissions:

Respiratory, pneumonia, COPD, asthma.

Cardiovascular, ischemic heart disease.

Other Markers of Acute Illness:

School absences, work days lost,

reduced activity days,

medications usage.

Health Effects: At Current Ambient Levels

♦ Morbidity or Physiologic Responses: Short-term (daily, multi-day) Exposures

- Acute Illness (Cohort, Panel Studies)
 - Aggravation of asthma, bronchitis
 - Increased risk of acute respiratory infection
- Physiologic Responses (Cohort, Panel Studies)
 - Increased heart rate, pulse rate
 - Decreased heart rate variability
 - Increased plasma viscosity
 - Decreased lung function (transient?)
 - Irritation of respiratory tract

Health Effects: At Current Ambient Levels

♦ Morbidity or Physiologic Responses: Long-term (months, years) Exposures

- Slowed lung function growth (children)
- Accelerated lung function decline (adults)
- Increased occurrence of respiratory disease or symptoms
- Elevated risk of bronchitis or chronic cough

Health Effects: Who Is Vulnerable?

♦ Short-Term

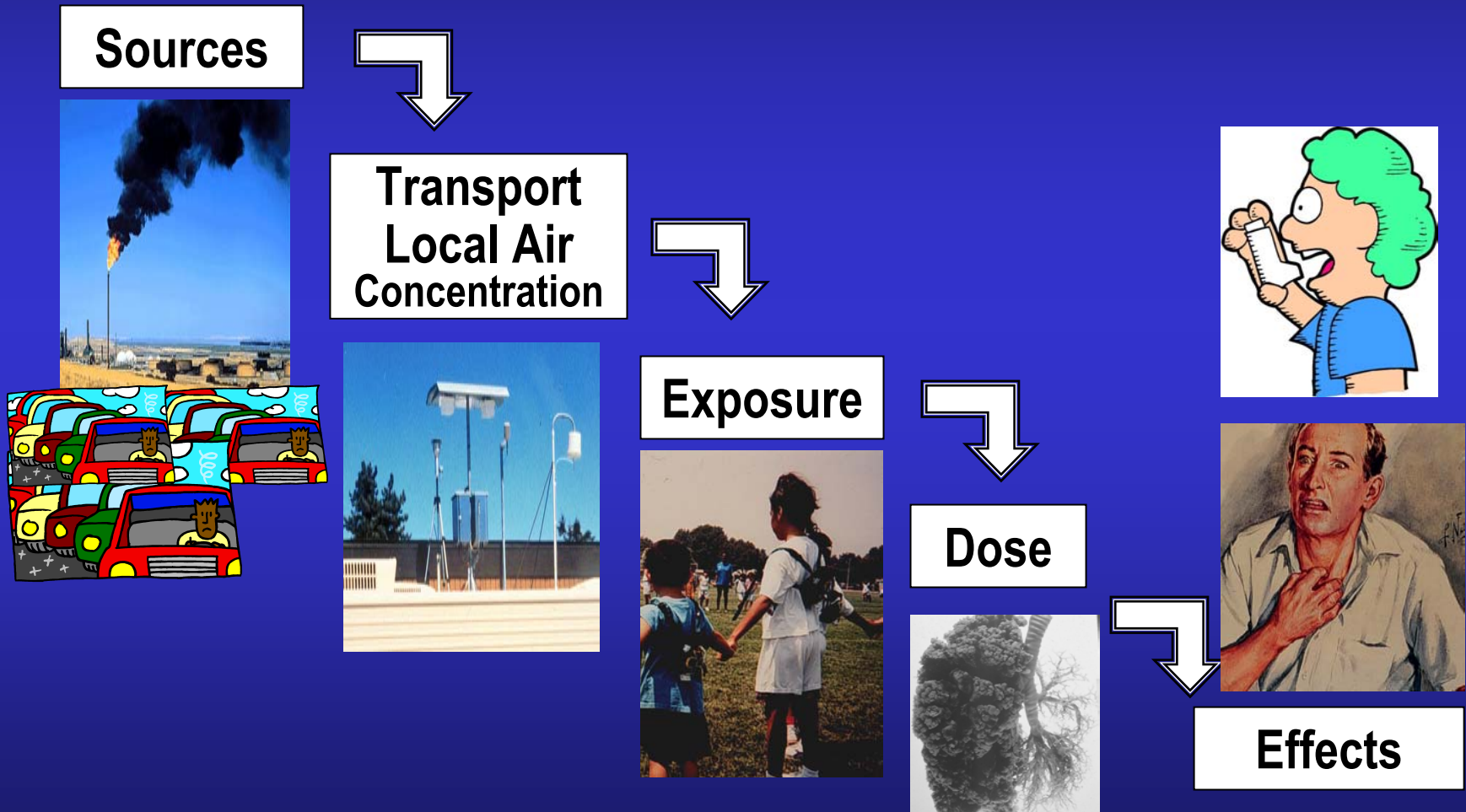
- Children (all ages)
 - pre - & post-natal
- Elderly People
- Heart Disease Patients
- Chronic Respiratory Disease Patients
- Asthmatics
- People with Bronchitis

♦ Long-Term

- Everyone

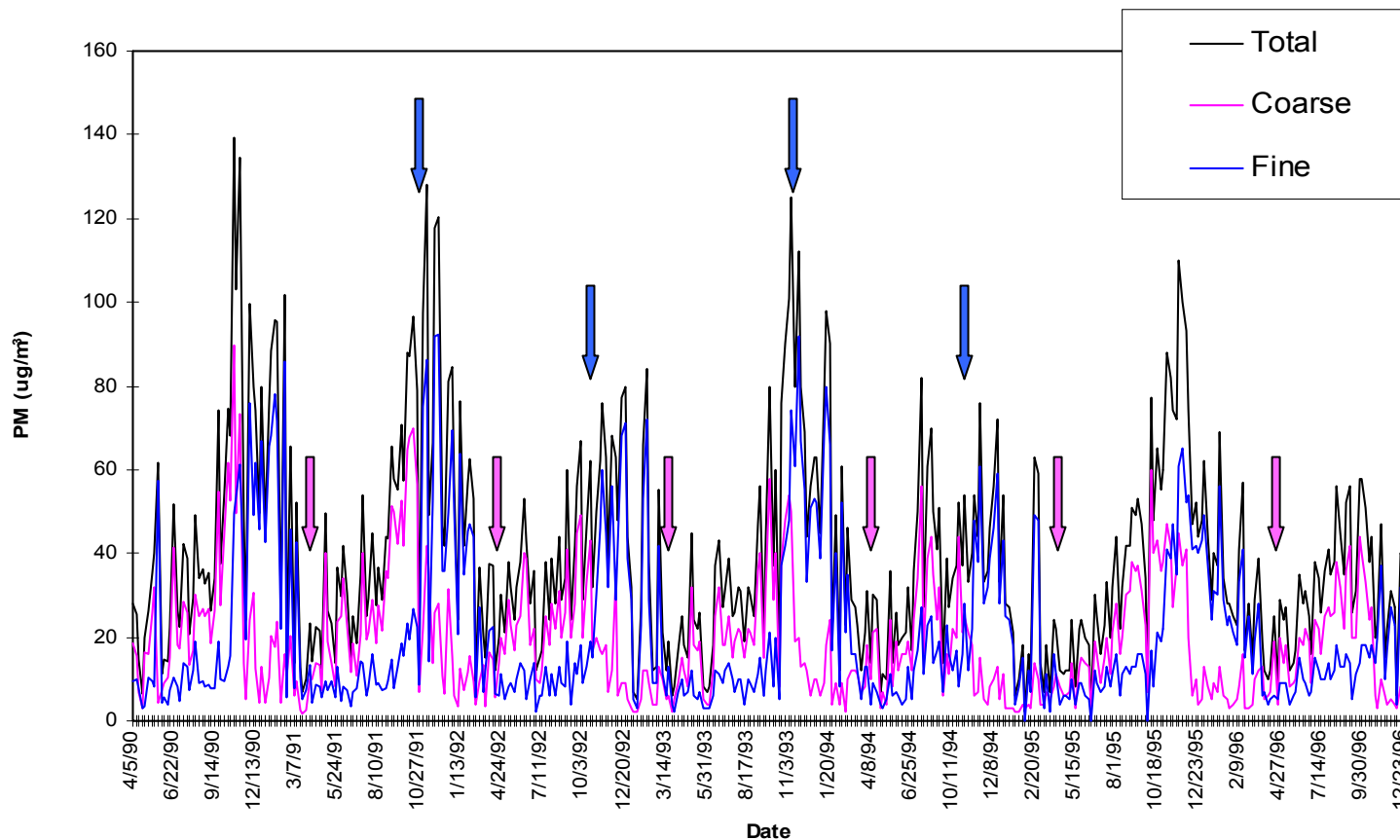


Exposure Considerations: Air Pollution -- From Source to Effects

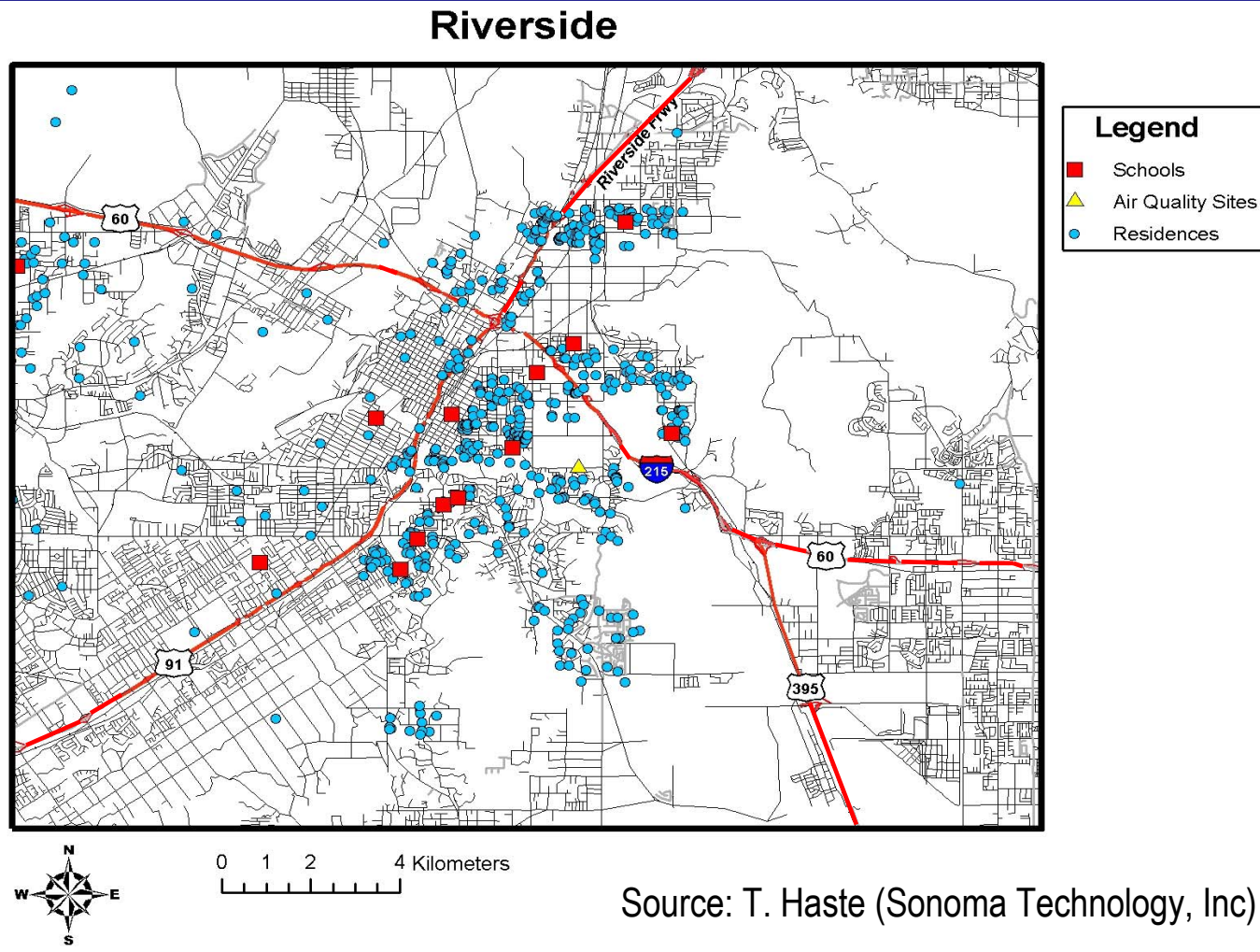


Exposure Considerations: Particulate Matter Temporal Variation

Time Series Plots of PM Mass (Dichot) -- Total PM10, Coarse, Fine
Fresno 1st Street

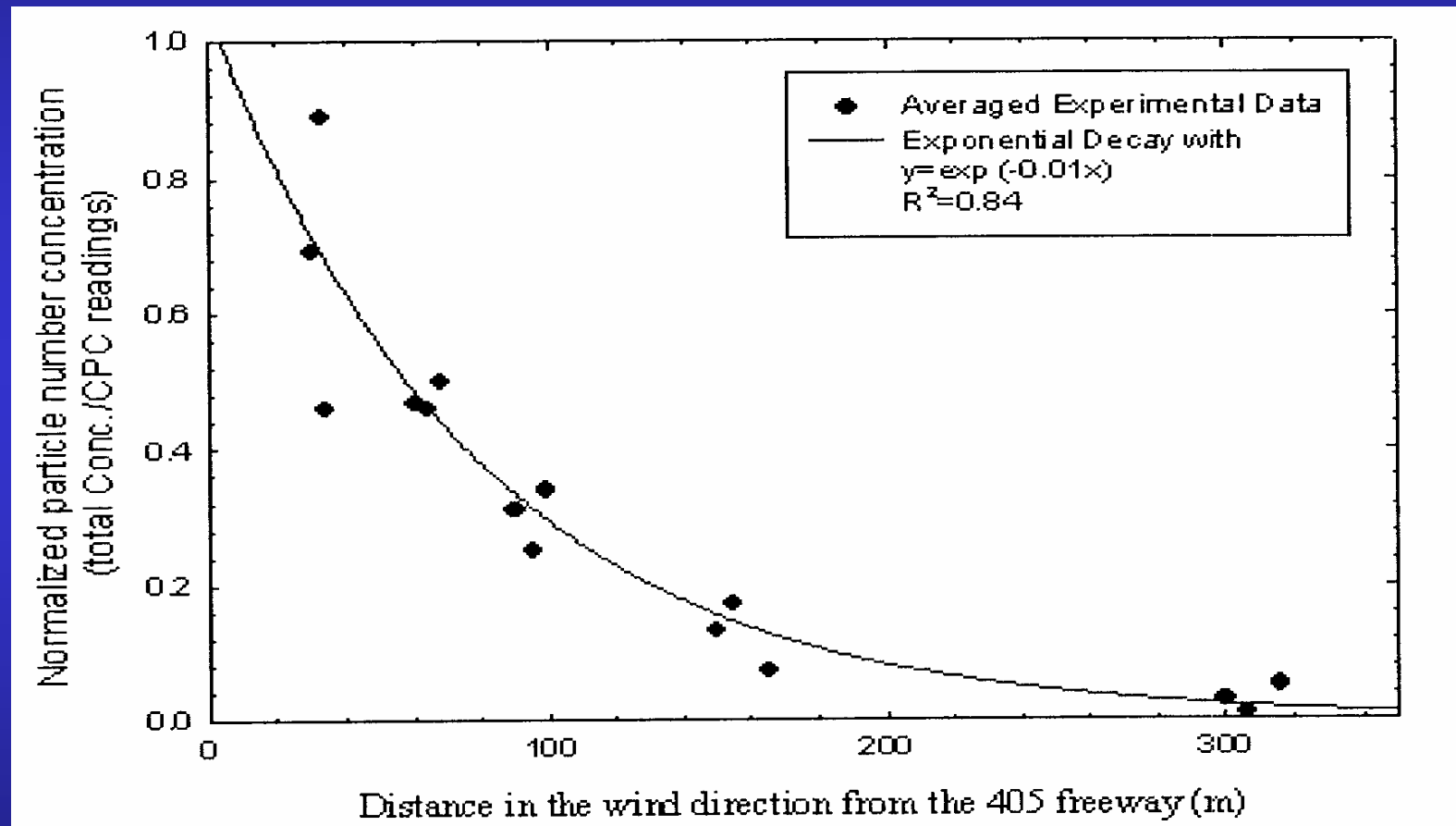


Exposure Considerations: Within Community Spatial Variation



Exposure Considerations: Within-Community Spatial Variation

Ultrafine particle counts drop with distance from highway

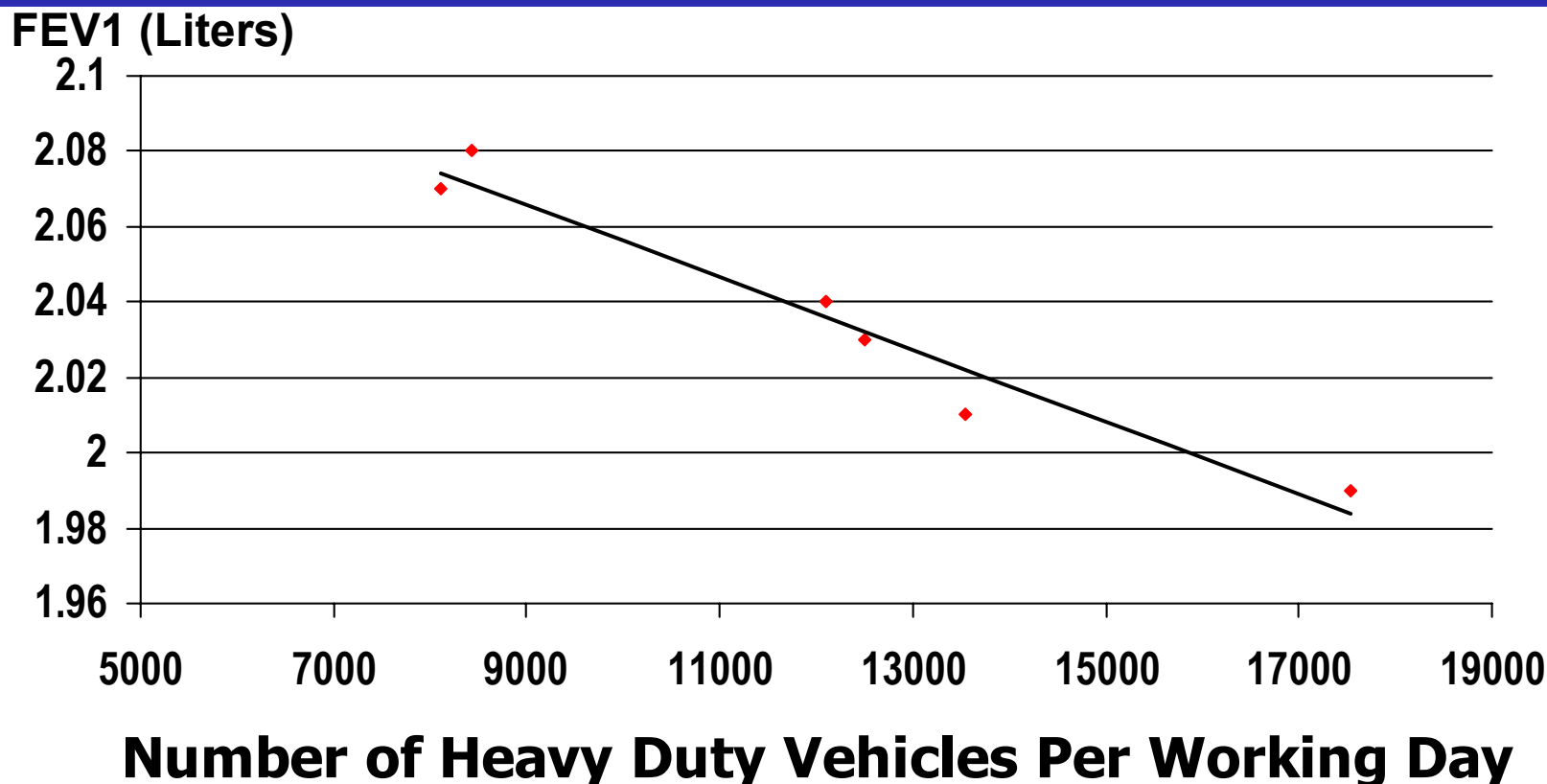


Source: Westerdahl, Bowers, Taylor: Presented at AAAR October 18, 2001

Data Source: Sioutas with permission, unpublished data

Exposure Considerations:

Association Between Lung Function of Children Living <300 Meters From Motorway and Intensity of Cargo Traffic



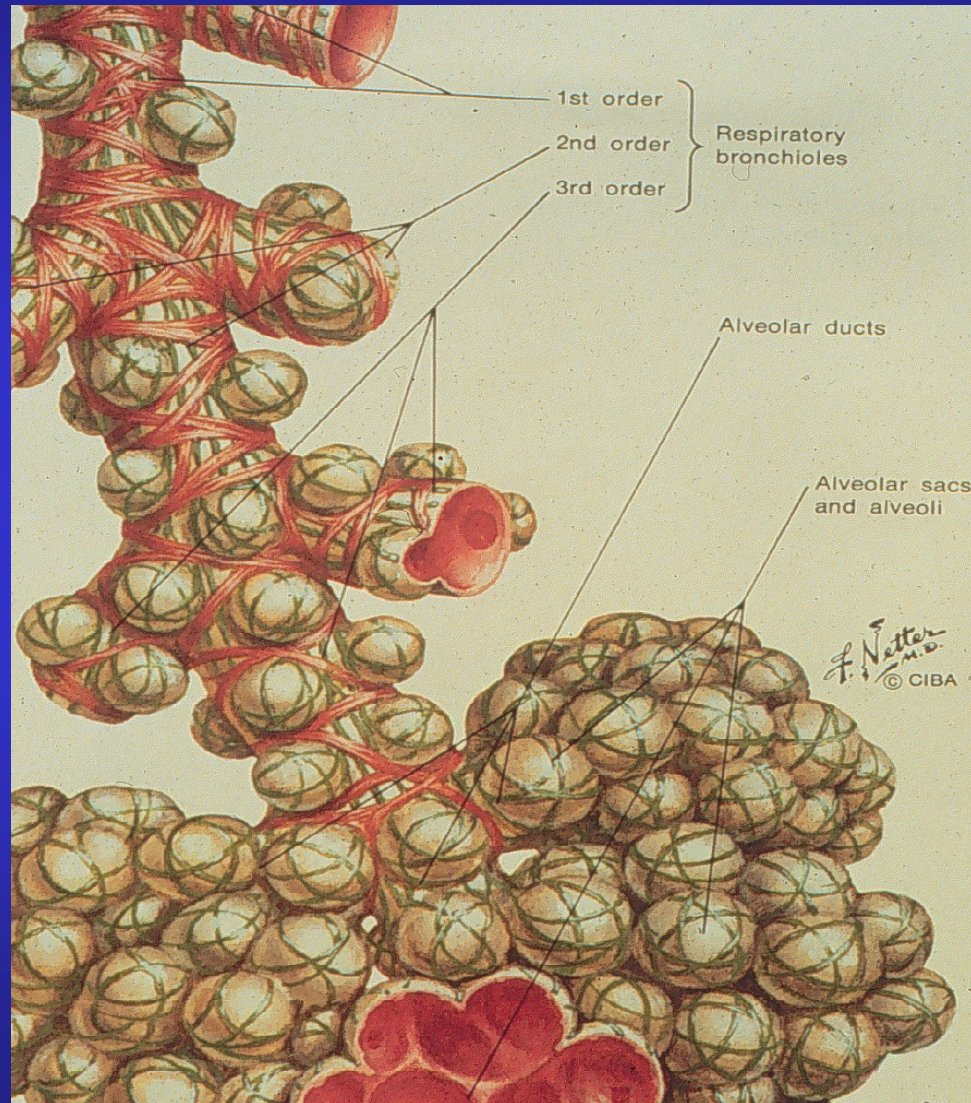
Source: Westerdahl, Bowers, Taylor: Presented at AAAR October 18, 2001

Source: Brunekreef B, et al, Air Pollution from truck traffic and lung function in children living near motorways

How can particulate matter cause adverse effects?

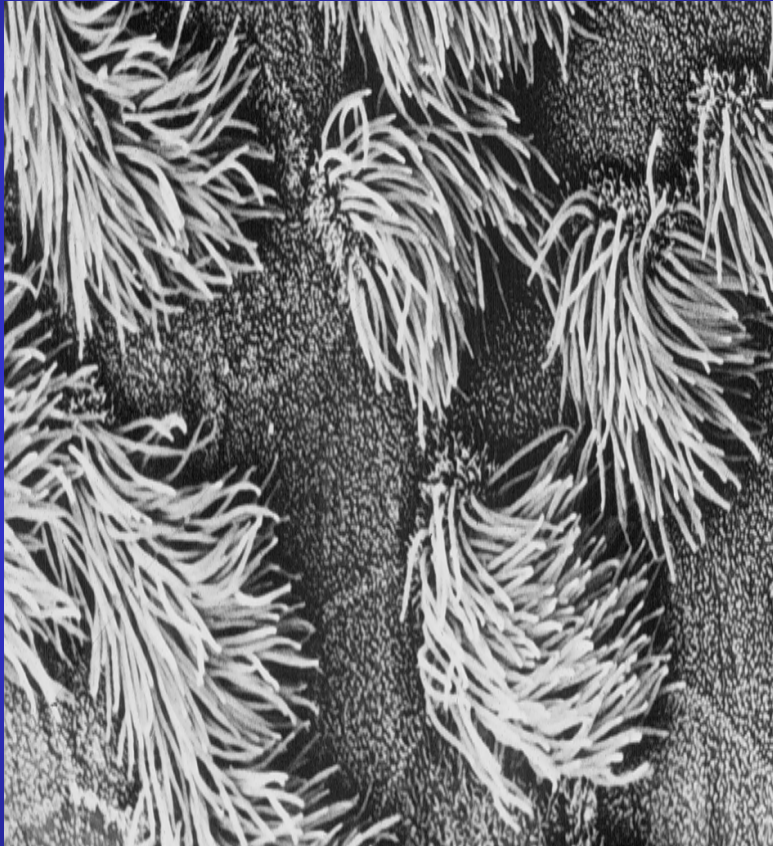


How can particulate matter cause adverse effects?

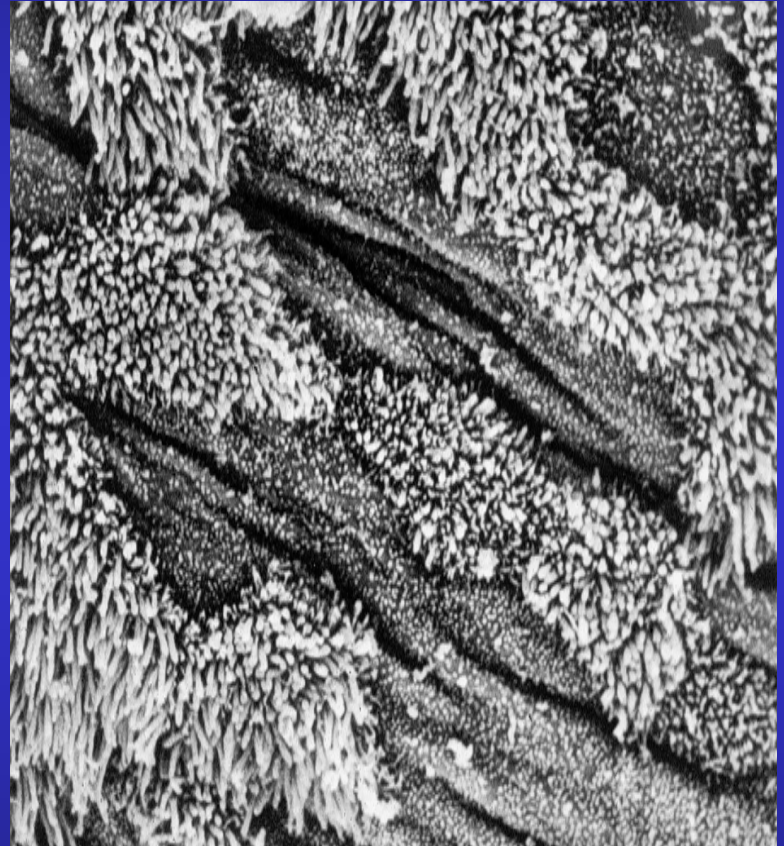


How can particulate matter cause adverse effects?

Alterations in Mucociliary Clearance: PM alone & in combination

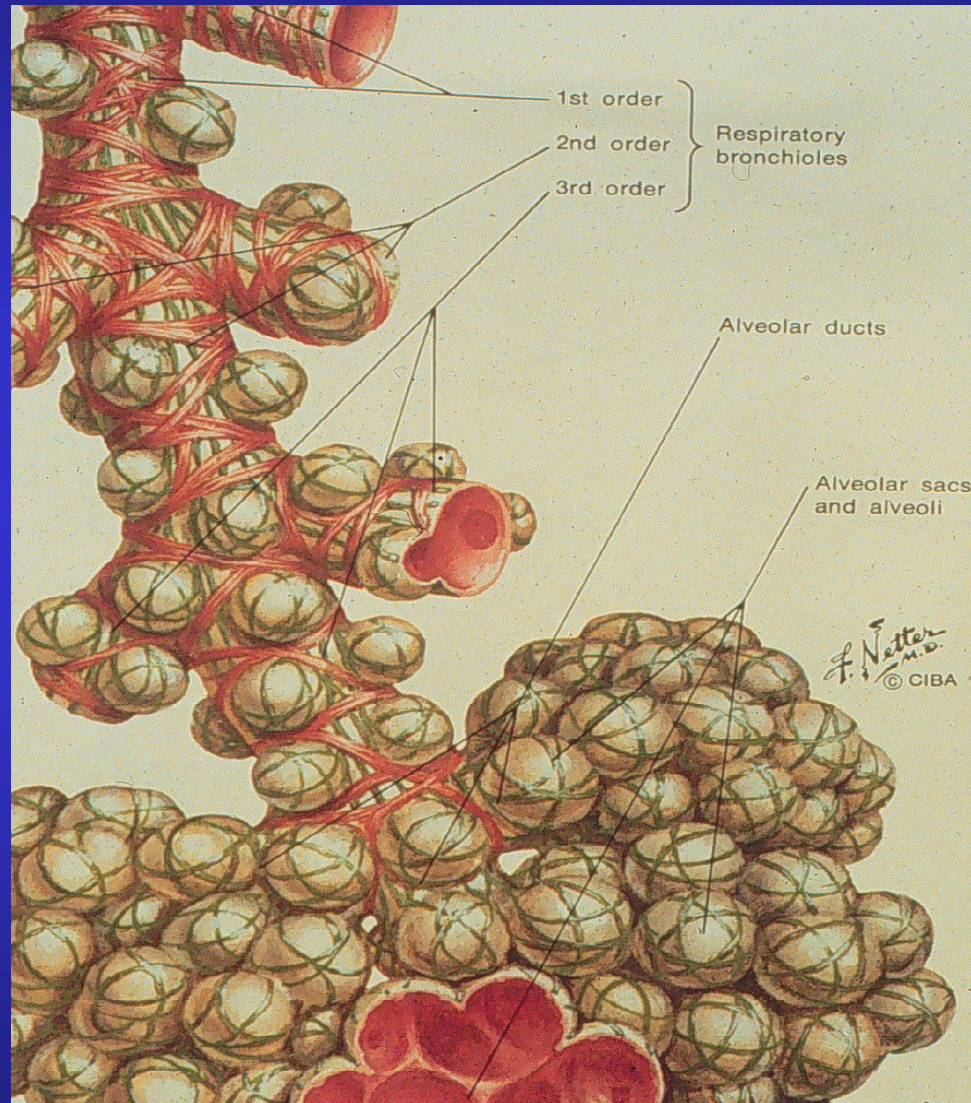


Cilia pre-NO₂ Exposure

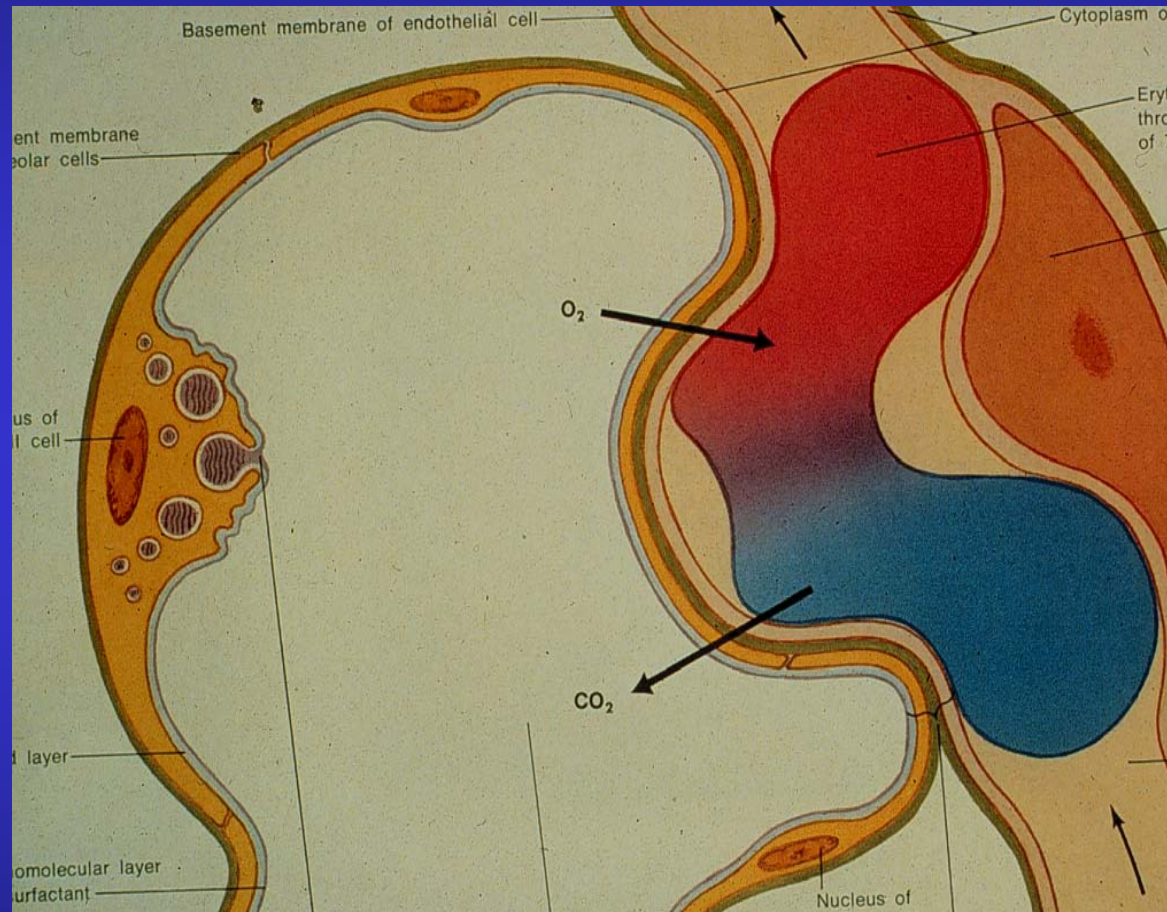


Cilia post-NO₂ Exposure

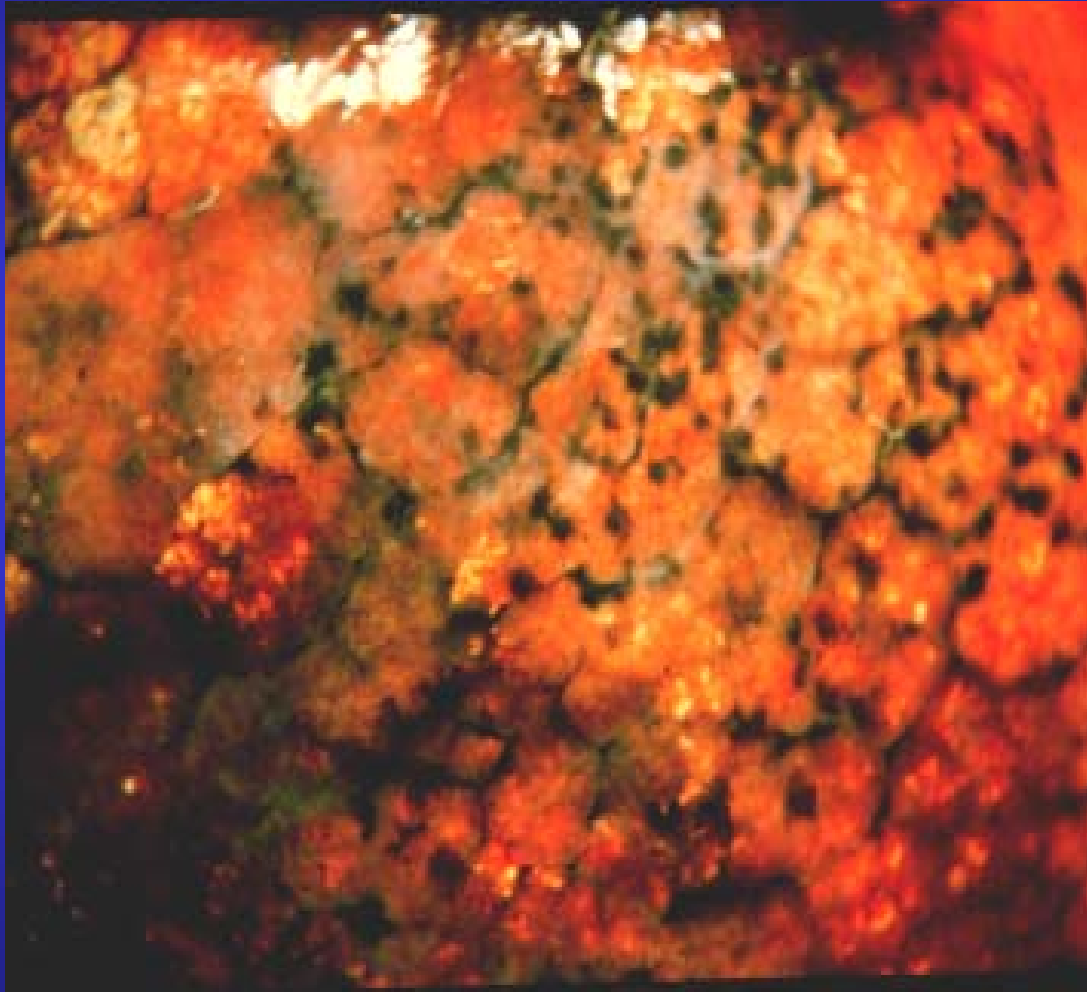
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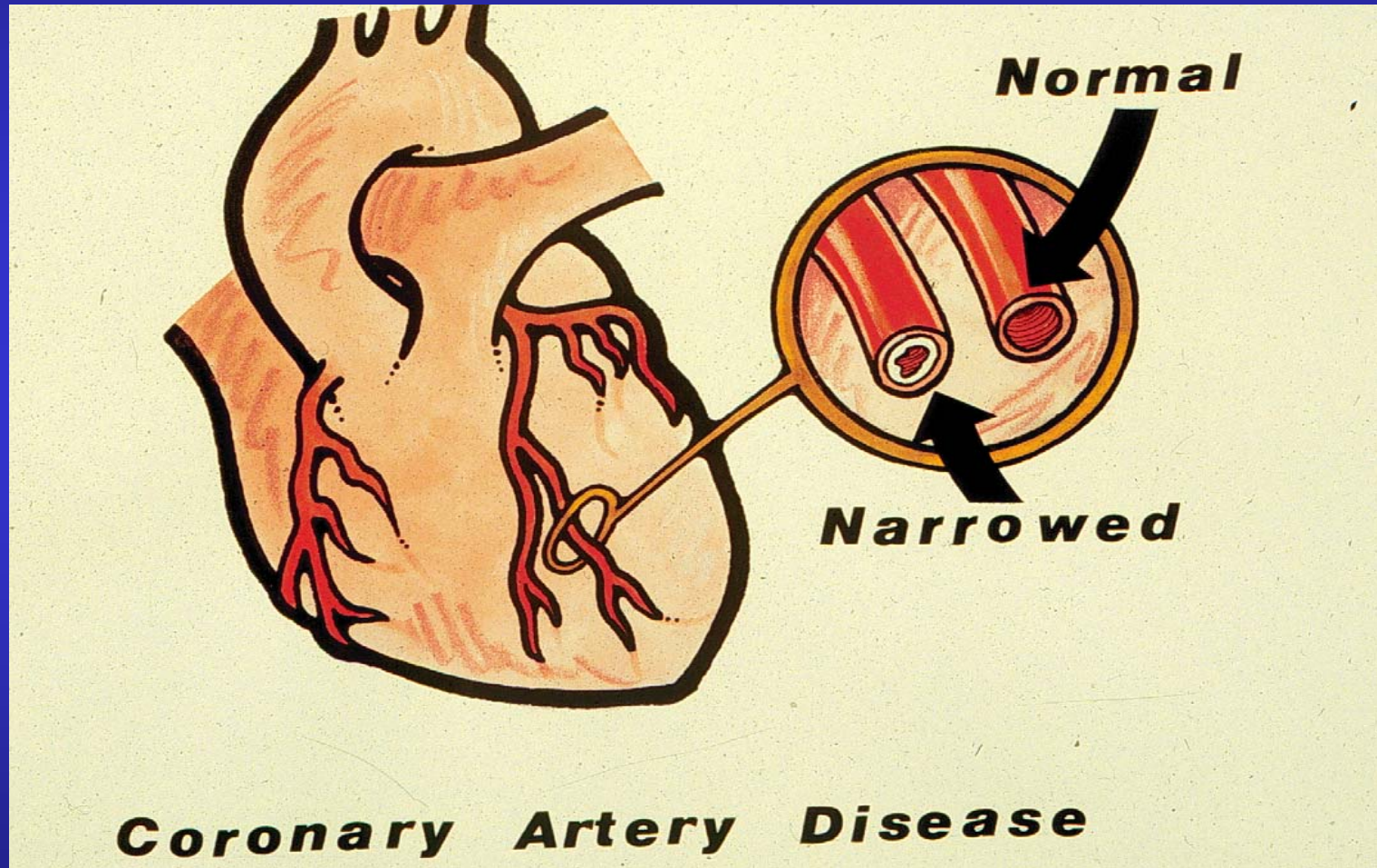
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How can particulate matter cause adverse effects?



How can particulate matter cause adverse effects?



Take-Home Messages: The Pieces of the Puzzle Fit

♦ The Evidence is Consistent:

Similar effects observed in numerous studies with diverse populations, environments, pollutant mixes.

♦ The Evidence is Coherent:

Physiologic Responses » Acute Illness » Hospitalizations » Death

♦ The Effects are Plausible:

Changes in physiologic & other biological measures are consistent with observed health effects --
including morbidity and mortality
from respiratory and cardiovascular causes.

Take-Home Messages

- ♦ **Public Health is Severely Impacted by PM**
Both morbidity & mortality risk increases.
Everyone is vulnerable...
Degrees of vulnerability depend on
biological susceptibility,
exposure and dose.
- ♦ **There are safe levels below which
no adverse health effects occur...
...but stay tuned.**

Take-Home Messages

- ♦ Collectively we can achieve sufficient reductions in particulate matter to protect public health.
- ♦ Until then...
we can limit exposure,
especially of susceptible populations --
the elderly, children of all ages,
patients with chronic illness.

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*Thank
You!*

